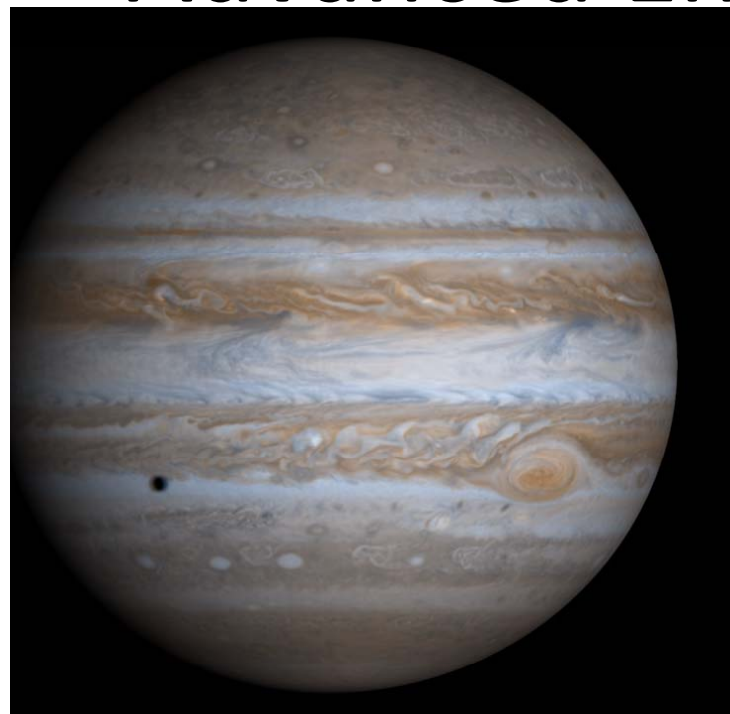


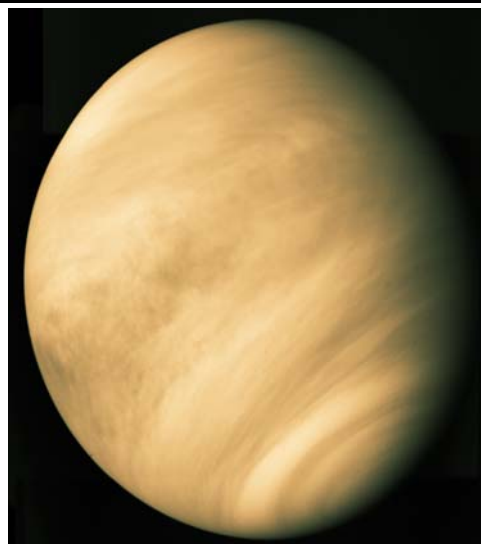
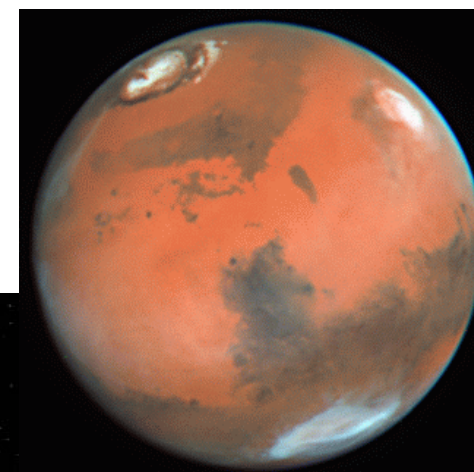
# Advanced Entry Systems Concepts

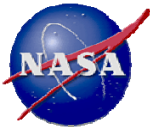


International Planetary Probe Workshop – 8  
Portsmouth VA  
June 4-10, 2011

[Charles.H.Campbell@nasa.gov](mailto:Charles.H.Campbell@nasa.gov)

NASA-JSC Applied Aerospence and CFD Branch/EG3

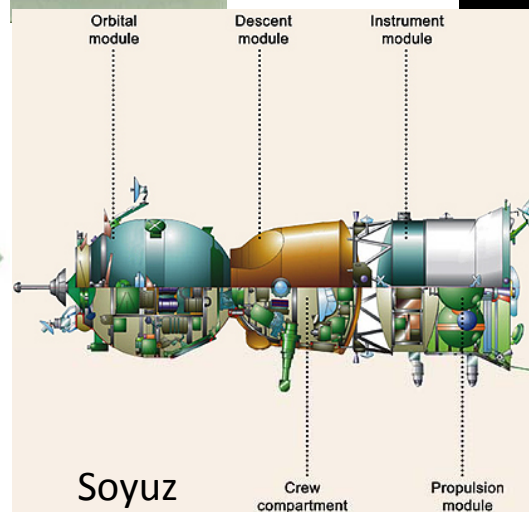
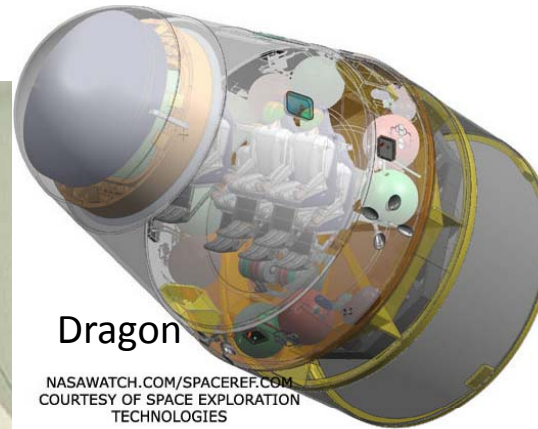
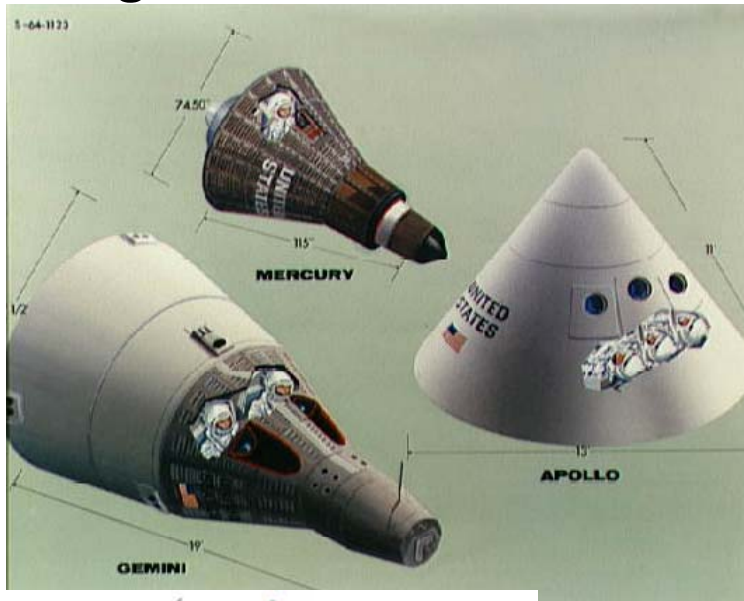




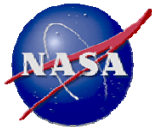
# Blunt Entry Vehicles



Majority of entry spacecraft are blunt vehicles flown with low lift-drag at trim conditions

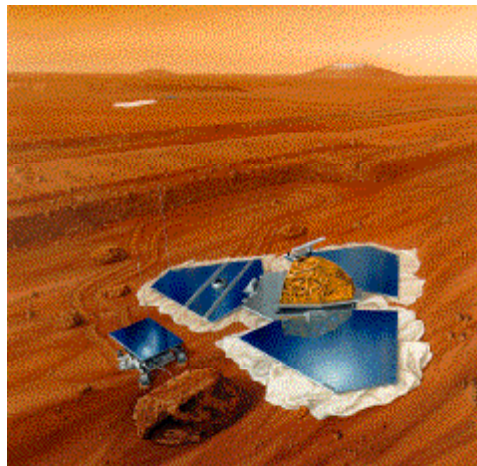
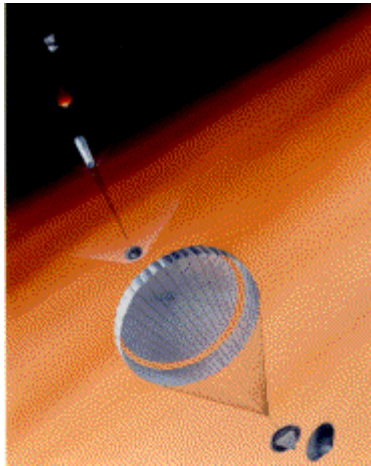






# Blunt Vehicle Landing Systems

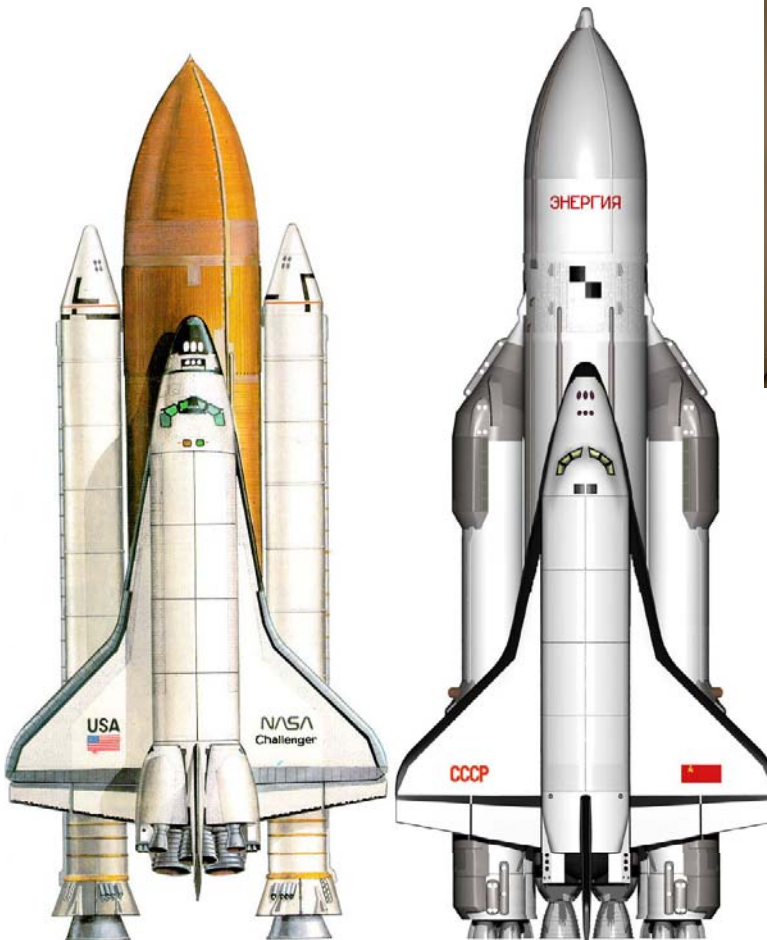
Pathfinder/Sojourner





# Lifting Entry Vehicles

Entry Vehicles that generate at least moderate lift-drag ratios are much less common. On Earth, they enable runway landing.....



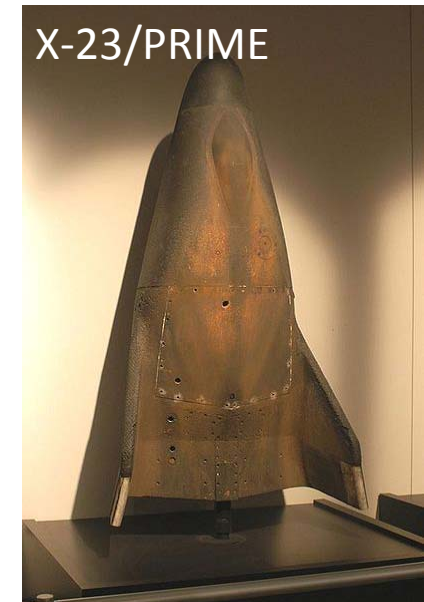
ASSET



Spaceship Two



Orbiter Discovery



X-23/PRIME



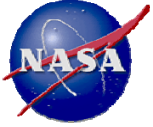
# Flight Test Vehicles



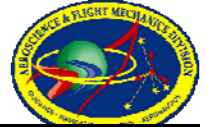
Testing of new technologies is critical to developing knowledge and experience necessary to utilize new approaches







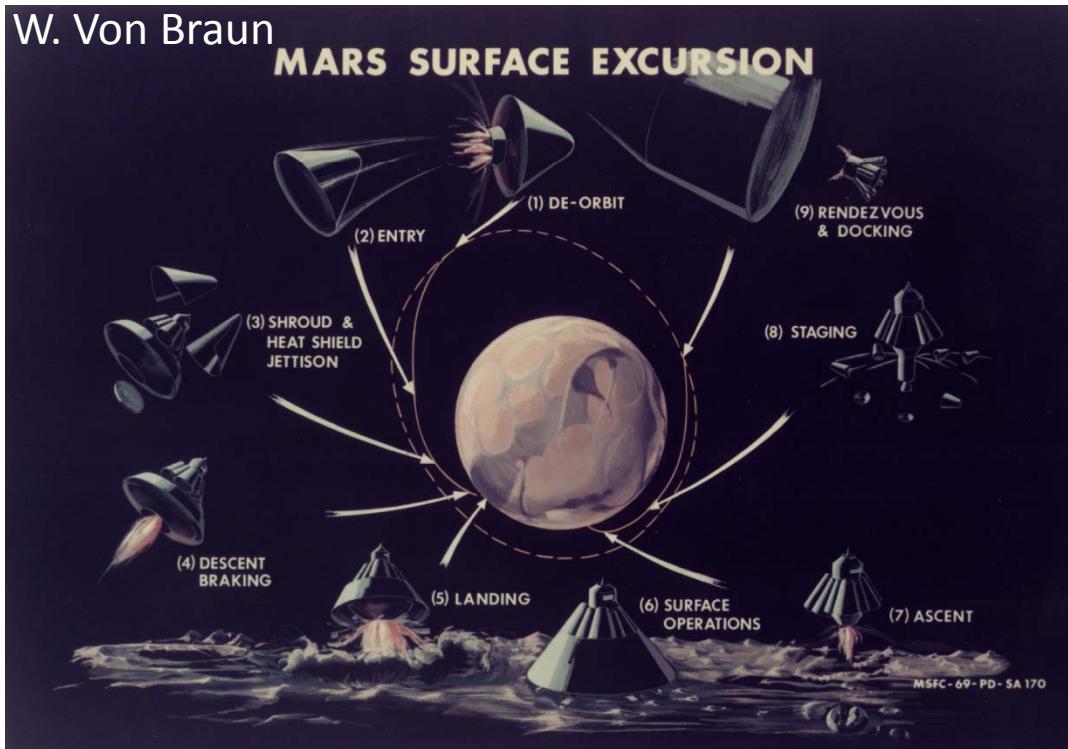
# Ideas from the Past can Inform Us

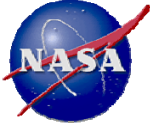


"FIRST" – Rogallo wing entry vehicle

W. Von Braun

## MARS SURFACE EXCURSION





# Entry Vehicle Concepts



## Exploration Systems MD

Constellation  
ETDD

## Space Operations MD

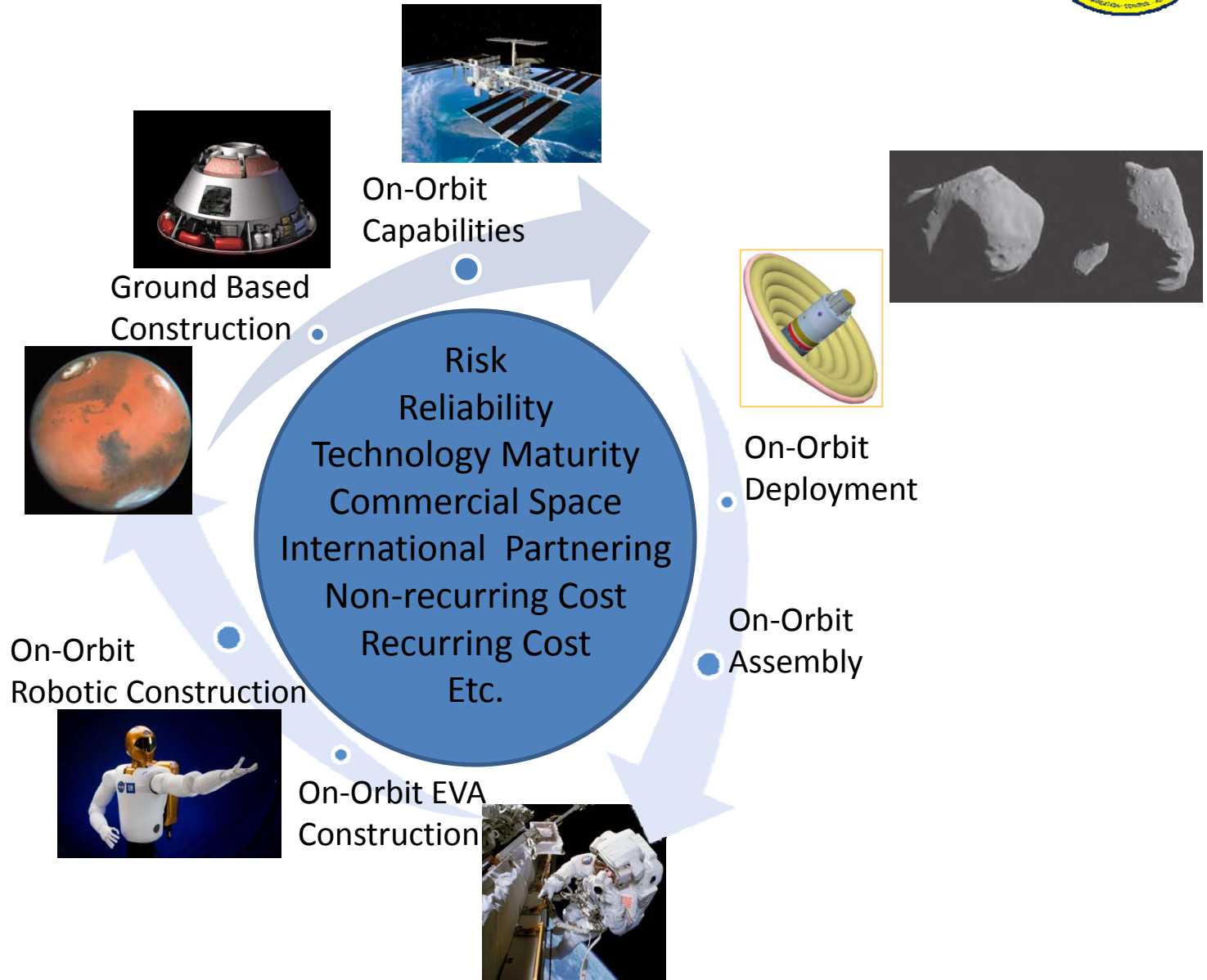
ISS Utilization  
CCDeV  
COTS

## Office of Chief Tech.

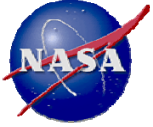
Early Stage Innovation  
Game Changing Tech.  
Cross Cutting Tech.

## Other Govm't Agencies

DARPA  
AFRL  
AFOSR  
DOE



*NASA OCT Grand Challenges can identify framework,  
and OCT/NRC Roadmapping can define goals.*

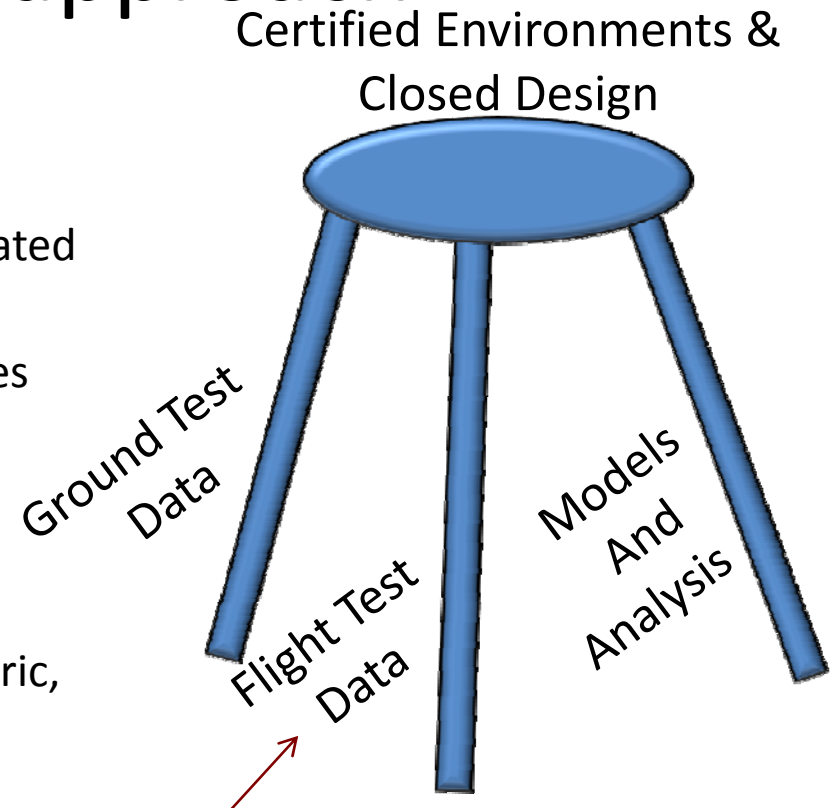


# Modeling / Ground /Flight Testing



## Three pronged approach

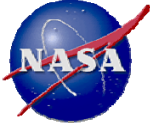
- Integrity of Flight Environments modeling *requires* 3-legged stool approach
- Demonstration of vehicle design margin requires application of flight relevant models validated/calibrated with ground and flight data
- Closing a design and certifying a flight vehicle requires an integrated modeling framework which captures all relevant phenomena
- Current SOA for integrated EDL analyses utilizes 6-DOF monte carlo with *simplified response models* using material, aero, aerothermodynamic, atmospheric, etc. databases
- Enhanced integrated entry analyses should leverage high fidelity response surface modeling and inclusion of detailed physical models where possible



Integrated Simulation is a surrogate for flight test data.

*An integrated analyses framework is required for DDT&E, and should be performed with the highest practical fidelity using comprehensive SOA.*





# Ideas that May Enable Future Capabilities



- Flexible Thermal Protection Systems
  - Combined aero/propulsive capabilities
  - Inflatable/Deployable approaches that are scalable across large range of masses
  - On-orbit construction of large vehicle systems
  - Supersonic Retro-Propulsion
  - Auto-rotation landers
  - More capable supersonic parachutes
- 
- Ultimately, the entry vehicle aerodynamics and controllability must provide for sufficient altitude to support deployment terminal guidance and touchdown systems
    - Is supersonic reconfiguration possible?
    - Is sufficient lift/drag provided to stage for terminal approach?
    - Are vehicle touchdown systems appropriate to the task of landing in a variety of gravitational and planetary surface characteristics?